Sectoral Shift, Wealth Distribution, and Development

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Abstract

There are two phenomena widely observed when an economy departs from an underdeveloped state and starts rapid economic growth. One is the shift of production, employment, and consumption from the traditional sector to the modern sector, and the other is a large increase in educational levels of its population. The question is why some economies have succeeded in such 'structural change', but others do not. In order to examine the question, an overlapping generations model that explicitly takes into account the sectoral change and human capital accumulation as sources of development is constructed and analyzed.

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1 Introduction

There are two phenomena widely observed when an economy departs from an underdeveloped state and starts rapid economic growth. One is the shift of production, employment, and consumption from the traditional sector, such as traditional agriculture in rural areas and the urban informal sector, to the modern sector, such as commercial agriculture in rural areas and modern manufacturing in urban areas. The other is a large increase in educational levels of its population.[1] Since the modern sector requires a larger pool of skilled labor, it is easy to see that these phenomena are related. The question is why some economies have succeeded in such 'structural change', but others do not. In order to tackle the question, this paper constructs an overlapping generations model that explicitly takes into account the sectoral change and human capital accumulation as sources of development.

The model economy has two sectors, traditional and modern, each producing a different kind of final good. The traditional sector hires unskilled labor and the modern sector employs skilled labor and physical capital to produce the goods.[2] The market of the good produced in the traditional sector is closed domestically,[3] while the market of the good produced in the modern sector, which is also used as a capital good, and the factor market of physical capital are open internationally.[4]

An agent in the economy lives for two periods, the first as a child and the second as an adult. In childhood, she receives a transfer from the parent and allocates it between two investment opportunities, assets and education, in order to maximize future income. The investment in education is required to become a skilled worker and is individually profitable, although it is costly. The cost of education is the cost of hiring skilled workers as teachers. Since loan markets are nonexistent, tuition must be self-financed. Consequently, poor parents cannot make investments in educating their children despite its profitability, hence the investment decisions are affected by family income. In adulthood, the agent has a single child, earns income from work and assets, and spends on the consumption of goods produced in the two sectors and intergenerational transfers.

[1]Empirical facts on the sectoral shift are summarized in Syrquin (1988) and those on the education growth are surveyed in Schultz (1988).

[2]This assumption is made for simplicity. As long as the modern sector is more intensive in skilled labor and physical capital, main results remain unchanged.

[3]The traditional sector corresponds to traditional agriculture and the urban informal sector in a real economy, which can be considered as nontradable sectors. See the next section for more detailed explanations.

[4]Although the accumulation of physical capital too is an important issue for a developing economy, the paper focuses exclusively on the sectoral shift and human capital accumulation in order to simplify the analysis. By contrast, earlier theoretical attempts in development economics such as Lewis (1954) concern the problem of capital accumulation in industrialization of a low-income economy.

The initial situation is that a large portion of the population is in the traditional sector and remains unskilled. Since there is no room left for growth in the traditional sector, the economy must accomplish the relocation of resources from the traditional sector to the modern sector in order to achieve a higher standard of living. Without an increase in skilled labor, the economy stays largely traditional and its income remains low. More people must be educated, but many of them are credit constrained and cannot make optimal investments. This is the difficulty the economy is facing when it tries to change the sectoral composition and achieve a higher income level. Under what conditions can such an economy succeed?

The first point of the paper is that an economy must start with an initial wealth distribution that gives rise to an adequate size of 'middle class' (those who have enough wealth to take education) for the successful sectoral change and development. The requirement for the 'take-off' in this economy is sizable wealth accumulation by a portion of unskilled workers so that their children can take education and get skilled jobs in the modern sector. The source of labor income of unskilled workers is sales of the good produced in the traditional sector. The price of the good in turn depends positively on the number of skilled workers and aggregate assets: a greater number of skilled workers implies higher demand and lower supply of the good, and larger asset accumulation leads to the higher demand. Thus, for the sectoral shift to start, a proportion of people who have enough wealth to take education and aggregate assets must be above certain levels.

If the initial wealth distribution is such that a larger portion of the population has access to education and becomes skilled workers, the price of the traditional good and thus the unskilled wage are higher. If the price level is above the critical level, a richer portion of unskilled workers can send their children to school and the sectoral shift starts immediately. Even when the initial price level is not high enough for the shift due to modest wealth accumulation, the larger pool of skilled workers makes rapid wealth accumulation possible, hence the price level rises to the critical level eventually and the economy 'take offs'. Once the sectoral change starts, it continues *autonomously.* An increase in the number of skilled workers raises the demand for the good, reduces its supply, and stimulates asset accumulation. All contribute to further increases in the price of the good and the unskilled wage. This allows children of less affluent unskilled workers to access education and thus increases the number of skilled workers further, lifting the price and the unskilled wage even more. As long as the skilled wage (net of the cost of education) is higher than the unskilled wage, this process continues. In the long run, the economy reaches the state in which the return from education is equated with that from assets, thus equal opportunity is attained.[5]

In contrast, if the economy starts with a relatively small size of 'middle class', the number of skilled workers is smaller, hence the price of the good produced in the traditional sector is lower. Children of unskilled workers are not financially able to obtain education and the number of skilled workers does not increase. Since skilled labor remains scarce, inequality between skilled and unskilled workers does not disappear and the investment choices are affected by family income even in the long run.

However, a 'good' initial wealth distribution is *not* sufficient for the success when there is the sectoral shift of consumption, i.e. preferences are such that the income (and price) elasticity of demand for the good produced in the traditional sector is smaller than one, while those for the good produced in the modern sector and the transfer are more than one. In this case, if the productivity of the traditional sector is very low, the economy ends up in a steady state with persistent inequality *irrespective* of the initial distribution and the productivity level of the modern sector. Thus, sufficient productivity in the sector is a prerequisite for the sectoral shift. Since the price elasticity of the traditional good is lower than one, when the productivity of the sector is lower, its price becomes higher more than proportionally and the unskilled wage rises. The resultant lower return from education implies that the economy can sustain fewer skilled workers and aggregate assets. If the productivity is below a certain level, the sustainable skilled labor and aggregate assets become smaller than the levels required for the 'take-off' and thus the sectoral shift does not start.

The argument so far has assumed time-invariant productivities for the both sectors. The above results are mostly *not* affected by the introduction of productivity growth, as long as the cost of education increases with the skilled wage. Still, an economy starting with an unproductive traditional sector is unlikely to succeed in the structural change, irrespective of its initial wealth distribution.

Empirical findings largely support the model's implications. The first point of the paper, the importance of initial wealth distribution, especially the size of 'middle class', in economic development, through its effect on human capital accumulation, has been backed by many studies. Using

[5]Larson and Mundlak (1997) finds that the ratio of average labor productivity of agricultural workers to that of non-agricultural workers converges to one as an economy develops. Some evidence indicates that the size of the informal sector and the wage differential between the informal and formal sectors decrease with development through human capital accumulation (Marcouiller et al., 1997; Ranis and Stewart, 1999).

panel data of wider coverage and of higher quality than those of earlier studies, Deininger and Squire (1998) and Deininger and Olinto (2000) discover that an economy's growth rate is affected negatively by initial land inequality (a proxy for initial asset inequality) and positively by its mean years of schooling per working person (a proxy for human capital).[6] Further, they find that the average educational attainment is negatively affected by initial land inequality, the effect of human capital is larger for a lower-income economy, and initial land and income inequality affect negatively income growth of the poor, but not of the rich. Using cross-sectional data from the 1960s to the 1990s, Easterly (2001) finds that a larger size of 'middle class', measured as the share of income held by the second through fourth quintiles of the distribution, is associated with more education, especially at secondary education, higher income, and higher growth.

The second point of the paper, sufficient productivity in the traditional sector as a precondition for a successful sectoral shift, has not been formally tested, although there are several findings indirectly supporting the claim. Bairoch (1975) points out the large gap (about 45 percent) in agricultural productivity on average between European countries at the onset of their industrial revolutions and Africa and Asia in 1960s. Further, Hayami and Ruttan (1985) finds a close positive association between overall output growth and agricultural productivity growth for Sub-Saharan African nations.

This paper is mainly related to two strands of literature. One is the literature that investigates mechanisms and outcome of sectoral change, such as Matsuyama (1992), Echevarria (1997), Kongsamut et. al. (2001), Laitner (2000), and Ngai and Pissarides (2004). Matsuyama investigates the role of agricultural productivity in economic development using a two-sector endogenous growth model and shows how openness of markets affects the relationship between productivity and growth. Using a Solow-type model with multiple consumption goods and non-homothetic preferences, Echevarria numerically shows that uneven productivity growth among sectors can lead to different aggregate growth rates at different stages of development. Kongsamut et. al. and Ngai and Pissarides study multi-sector growth models related to the one investigated by Echevarria and derive conditions for structural change and balanced growth. Laitner explains how an economy's measured average propensity to save rises in the course of industrialization by focusing on the increasing importance of reproducible capital relative to land.

[6]Unless aggregate wealth accumulation is very low, a more equal wealth distribution implies that a larger proportion of individuals can take education.

The other is the large literature that investigates the interplay between income distribution and growth theoretically, which includes Banerjee and Newman (1993), Galor and Zeira (1993), Ljungqvist (1993), Persson and Tabellini (1994), Benabou (1996a, 1996b), Benhabib and Rustichini (1996), Durlauf (1996), Aghion and Bolton (1997), and Lloyd-Ellis and Bernhardt (2000). Closely related is the paper by Galor and Zeira, which show how credit constraints and lumpy investment in human capital can create the interaction between initial distribution and long-run outcome of an economy in a model with a single final good. Wages are determined purely technologically in their papers, while the unskilled wage in the present model is affected by demand factors as well. They are not concerned with sectoral shifts of production and consumption.

The paper is organized as follows. Section 2 presents the model without the sectoral shift of consumption. Section 3 derives and analyzes the model's dynamics and Section 4 presents and interprets the results from the basic model. In Section 5, the sectoral shift of consumption is introduced into the model and its implications for the results are examined. Section 6 concludes the paper.

2 Model

2.1 Individual decisions

Time is discrete and starts from 0. There is no uncertainty. The economy is composed of a continuum of individuals who live for two periods, the first period as children and the second period as adults.

2.1.1 Investment decisions

In childhood, an individual receives a transfer from her parent. Then she allocates the transfer for two investment options, assets and education, in order to maximize future income.[7] Education, which would correspond roughly to secondary education in actual developing economies, is required to become a skilled worker and enjoy higher earnings in adulthood. The investment is a discrete choice, i.e. takes education or not, incurs a fixed cost, and brings the difference between the skilled wage and the unskilled wage as the gross return. Consider an individual who was born into lineage

[7] Alternatively, one can suppose that the investment decisions are carried out by the parent in order to maximize the child's future income. Note that the transfer in the model corresponds to total intergenerational transfers including bequests, education, and other inter-vivos transfers in real life. The decision that the child (or the parent) has to make is the allocation of the whole transfers between education and assets.

i in period $t-1$. Her generation is called *generation* t. Then, her education costs e_t, and its gross return is $w_{H,t}-\ w_{L,t}$ in the next period, where $w_{H,t}$ and $w_{L,t}$ are skilled and unskilled wages in period t, respectively. Assume that the education cost is the cost of hiring current skilled workers as teachers and it is proportional to $w_{H,t-1}$, i.e. $e_t = s_e w_{H,t-1}$, where s_e is a constant.[8] The investment must be self-financed because loan markets for such investment are not available: the child's future income is not a valid collateral in the financially underdeveloped economy. The other option, the investment in assets, is a continuous choice, and brings a gross rate of return of $1 + r_t$. It is easily shown that, in an equilibrium, the return from the investment in education becomes at least as high as the return from the investment in assets, i.e. $w_{H,t}-\ w_{L,t} \geq (1 + r_t)e_t$.

Suppose that the individual has received b_t^i units of income as a transfer from the parent. If the return from the investment in education is strictly higher than that from the investment in assets, optimal investment choices of assets a_t^i and education e_t^i are given by the following equations:[9]

$$\text{If} \quad b_t^i < e_t, \quad a_t^i = b_t^i, \qquad e_t^i = 0, \tag{1}$$

$$\text{and if} \quad b_t^i \geq e_t, \quad a_t^i = b_t^i - e_t,\ e_t^i = e_t. \tag{2}$$

Since innate abilities of individuals are identical, transfers *solely* determine the investment and resulting occupational choices.

2.1.2 Consumption and transfer decisions

An adult individual, who is either a skilled or unskilled worker depending on the human capital investment in the previous period, obtains income from assets and labor supply and spends the income on consumption and transfer to her child. Each adult is assumed to have a single child. There are two different consumption goods, good L and good H. Characteristics of these goods are described later in this section. Assume that an adult individual of lineage i in generation t has the following preference:

$$U_t^i = (c_{L,t}^i)^{\gamma_l}(c_{H,t}^i)^{\gamma_h}(b_{t+1}^i)^{1-\gamma_l-\gamma_h}, \tag{3}$$

[8] Kendrick (1976) finds that teacher and student time constitute about 90% of all costs of education. Further, World Bank (1983) notes that about 95% of current expenses in primary school systems of low income countries are teacher salaries. In addition to direct costs of education, foregone earnings are important costs particularly in a low income economy. Results are not affected by the inclusion of foregone earnings to the cost.

[9] Actually the relative return from education is determined as the result of people's investment decisions, since it depends on the numbers of skilled and unskilled workers in the economy. More formal analysis of the investment decision is described in the next section.

where $c^i_{L,t}$ and $c^i_{H,t}$ are her consumption of good L and good H, respectively and b^i_{t+1} is the transfer to the child (generation $t+1$). Denote the relative price of good L to good H in period t by P_t. The budget constraint takes the following form:

$$P_t c^i_{L,t} + c^i_{H,t} + b^i_{t+1} = w^i_t + (1+r_t)a^i_t, \tag{4}$$

where w^i_t is her earnings.

Maximization of the utility function (3) subject to the budget constraint (4) gives the following consumption and transfer rules:

$$P_t c^i_{L,t} = \gamma_l[w^i_t + (1+r_t)a^i_t], \tag{5}$$

$$c^i_{H,t} = \gamma_h[w^i_t + (1+r_t)a^i_t], \tag{6}$$

$$\text{and} \qquad b^i_{t+1} = (1-\gamma_l-\gamma_h)[w^i_t + (1+r_t)a^i_t]. \tag{7}$$

2.1.3 Generational structure

At the beginning of period $t+1$, current adults pass away, current children become adults, and new children are born into the economy. Since each adult has one child, the population is constant over time. The population of each generation is normalized to be one.

2.2 Production structure

There are two production sectors, sector L (the traditional sector) and sector H (the modern sector) in the economy. Sector L employs unskilled workers to produce good L, and sector H employs skilled workers and physical capital to produce good H. Good H is used for investment in physical capital as well.

The production functions of the two sectors are given as follows:

$$\text{Sector L:} \quad Y_{L,t} = A_{L,t}L_t, \tag{8}$$

$$\text{Sector H:} \quad Y_{H,t} = A_{H,t}(H_{H,t})^{\alpha}(K_t)^{1-\alpha}. \tag{9}$$

In the above expressions, $Y_{L,t}$ and $Y_{H,t}$ are outputs of good L and good H, respectively, $A_{L,t}$ and $A_{H,t}$ are the productivity levels of the respective sectors, L_t is the number of unskilled workers, $H_{H,t}$ is the number of skilled workers in sector H (the rest of skilled workers are employed in the education sector), and K_t denotes physical capital in the economy. To focus on main mechanics of the model, in most parts of the paper, the productivities $A_{L,t}$ and $A_{H,t}$ are assumed to be constant over time, i.e. $A_{L,t} = A_L$ and $A_{H,t} = A_H$. As described later, the main results of the model remain intact with the introduction of exogenous productivity growth.

The assumptions that unskilled workers are employed only in sector L, and skilled workers and physical capital are employed only in sector H are made for simplicity. Provided that the former sector is more intensive in unskilled labor and the latter sector is more intensive in skilled labor, the outcome from the model remains mostly unchanged.

2.3 Market structure and determination of prices

Suppose that the markets for good L and for labor are closed domestically and their prices are determined within the economy, while good H and physical capital are freely mobile internationally. The assumptions on the final goods would be better understood by associating them with goods in an actual economy.

The first interpretation is that good L is agricultural goods produced with traditional technology, and good H is manufacturing or agricultural goods produced with modern technology. Traditional agriculture is engaged on a small scale by families located in rural areas and produces basic agricultural goods largely for subsistence. Because its productivity is low and transportation costs and traders' margins are high due to poor infrastructure and distribution system,[10] it supplies the product mostly for self-consumption and domestic markets. On the other hand, modern manufacturing and commercial agriculture compete more directly with foreign suppliers.

The second interpretation is that good L is non-tradable service or manufacturing goods produced with technologies intensive in unskilled labor, such as petty trading, personal services, and repairing services, and good H is manufacturing goods produced with technologies intensive in skilled labor and physical capital. That is, sector L and sector H may be considered as the informal and formal sectors of an urban economy. There is an evidence that shows that the size of the urban informal sector is substantial in most developing countries, in many cases accounting for over half of the urban workforce (Ranis and Stewart, 1999).[11]

[10] See, for example, Minten and Kyle (1999) for the evidence from former Zaire.

[11] Of course, in a real economy, there exist skill-intensive sectors that supply nontradable services and goods. However, in lower developing countries, most of skill-intensive nontradables are public services, health services, and education, where service prices and wages are determined by institutional factors rather than by market conditions, while nontradable sectors influenced more directly by market factors, such as financial services and consulting services,

Perfect mobility of physical capital is assumed because it is more realistic than the other extreme of the closed market, and it enables the paper to focus on human capital accumulation rather than physical capital accumulation as a source of growth.

From the assumptions, the interest rate is fixed at the world interest rate $r_t = r$, so the skilled wage w_H is given by the following equation.[12]

$$w_H = \alpha(A_H)^{\frac{1}{\alpha}}\big(\frac{1-\alpha}{r}\big)^{\frac{1}{\alpha}-1}. \tag{10}$$

The wage rate is exogenous, and without technological growth and fluctuations of the world interest rate, it is constant over time. The wage of unskilled workers is equal to

$$w_{L,t} = P_t A_L, \tag{11}$$

hence it depends on the relative price of good L to good H, P_t.

The relative price is determined by the market clearing condition of good L. The demand for good L is total consumption of the good by the adult population, which is the sum of individual consumption (5) over the population. So the market clearing condition becomes

$$P_t A_L L_t = \gamma_l\Big[w_{L,t}L_t + w_H H_t + (1+r)\sum_i a_t^i\Big]. \tag{12}$$

In the above equation, H_t is the total number of skilled workers, which is the sum of $H_{H,t}$ and $H_{E,t}$, the number of skilled workers in the education sector, and $\sum_i a_t^i$ is aggregate assets. Note that, due to free international capital mobility, it could be the case that a large portion of the assets were invested abroad, if there do not exist enough investment opportunities within the economy. By substituting (11) and $H_t + L_t = 1$ into the above equation and solving for P_t, the relative price of good L is given as follows:

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are limited in size. By comparison, as explained in the main text, traditional agriculture and the urban informal sector are important parts of unskilled-intensive sectors in developing countries. Hence, the assumption on the tradability of two final goods would be justified. Note that, as mentioned in the previous subsection, the assumption that sector H employs only skilled labor and physical capital and sector L employs only unskilled workers can be relaxed without affecting main results.

[12]From the first order conditions of the profit-maximizing problem of the firm in sector H, the following two equations are derived.

$$r_t = (1-\alpha)A_H\Big(\frac{H_{H,t}}{K_t}\Big)^{\alpha},$$

$$\text{and} \quad w_{H,t} = \alpha A_H\Big(\frac{K_t}{H_{H,t}}\Big)^{1-\alpha}.$$

Solving the first equation for $\frac{H_{H,t}}{K_t}$, substituting it into the second equation, and setting $r_t = r$ gives (10).

$$P_t = \frac{\gamma_l}{1-\gamma_l} \frac{w_H H_t + (1+r)\sum_i a_t^i}{A_L(1-H_t)}. \tag{13}$$

The relative price P_t increases with the number of skilled workers H_t and aggregate assets. Larger H_t and $\sum_i a_t^i$ imply greater total income and higher demand of good L, and larger H_t (smaller L_t) implies lower supply of the good, hence higher P_t. Since $w_{L,t} = P_t A_L$, the unskilled wage is also increasing in H_t and $\sum_i a_t^i$.

For analyses in later sections, it is convenient to express the relative price as a function of H_t and aggregate intergenerational transfers, B_t, by substituting $\sum_i a_t^i = B_t - eH_t$ into the above equation (13):[13]

$$P_t = \frac{\gamma_l}{1-\gamma_l} \frac{[w_H - (1+r)e]H_t + (1+r)B_t}{A_L(1-H_t)}. \tag{14}$$

The relative price and the unskilled wage are increasing in both H_t and B_t. To express the dependency of P_t and $w_{L,t}$ on H_t and B_t, they are denoted as $P(H_t, B_t)$ and $w_L(H_t, B_t)$, respectively.

The education sector employs skilled workers as teachers to provide educational services to students. Since tuition equals e and the number of students is H_{t+1} in period t, the market clearing condition of the sector is

$$w_H H_{E,t} = eH_{t+1}, \tag{15}$$

$$\text{or} \quad H_{E,t} = s_e H_{t+1}. \tag{16}$$

The above equation shows that the constant s_e represents the number of teachers needed to teach one student. It is assumed that $s_e < 1$ is low enough that the above condition is satisfied without rationing: if s_e is high, not all children who have enough wealth to pay tuition can receive education because there are not enough teachers.

3 Dynamics

In the model economy, individuals live only for two periods and participate in each market for one period alone: each market consists of individuals of a single generation each period. Hence, the model can be considered as a sequence of static economies.

[13] The relation $\sum_i a_t^i = B_t - eH_t$ is satisfied since current skilled workers have spent e on education out of their received transfers in the previous period. Note that the cost of education e is time-invariant because the skilled wage w_H is constant over time.

What connects these static economies across periods are intergenerational transfers. Because of the credit constraint, transfers directly affect individuals' investment and occupational choices, and consequently consumption and transfer decisions. Further, the distribution of transfers over the population determines the proportion of individuals who can afford to take education, and thus it affects the relative return from education and investment decisions. Hence, in general, the time evolution of the distribution of transfers must be examined in order to understand how the economy's structure, such as production and employment shares of each sector, total output, or earnings and asset distributions, change over time.

This section first derives the dynamic equation relating the current period's transfer to the next period's transfer within a lineage (*individual dynamics*). The dynamics depend on the time evolution of two aggregate variables that in turn are determined by the dynamics of the distribution of transfers. However, it turns out that, sufficient information for obtaining the model's implications is the directions of motion of the aggregate variables, which can be derived without knowledge on the distributional dynamics. Hence the dynamics of the two aggregate variables are characterized next. Although the two dynamics interact, for exposition, initially the dynamics of each variable are analyzed fixing the other, then the both dynamics are analyzed together by introducing a phase diagram.

3.1 Individual dynamics

Consider an individual born into lineage i in period $t-1$, who belongs to *generation* t. She allocates transfer b_t^i between investments in assets a_t^i and in education e_t^i so as to maximize future income. If the transfer is less than the cost of education, i.e. $b_t^i < e$, the transfer is spent only on assets and she becomes an unskilled worker as described above. On the other hand, if it is at least as large as the cost of education, i.e. $b_t^i \geq e$, the investment decision is more complicated. Since investment decisions of others affect the unskilled wage $w_L(H_t, B_t)$ and the relative return from education, the individual has to take into account their actions in making the decision. The key variable affecting the decision is the fraction of individuals in generation t who have received transfers b_t^i larger than e, Fr_t. In short, when only small numbers of individuals can afford education, all of them take education and become skilled, and when many individuals have access to education, some of them become skilled but others not.

3.1.1 Unequal opportunity case

When the proportion of individuals who can afford to take education is small, the return from education is higher than the return from assets, even if all of them actually take education, i.e. $w_H - (1+r)e > w_L(Fr_t, B_t)$. In this case, the individual allocates the transfer b_t^i between the investments in assets a_t^i and in education e_t^i in the following manner:

$$\text{If} \quad b_t^i < e, \quad a_t^i = b_t^i, \qquad e_t^i = 0, \tag{17}$$

$$\text{and if} \quad b_t^i \geq e, \quad a_t^i = b_t^i - e, \; e_t^i = e. \tag{18}$$

From the above equations, it is clear that all young individuals who are financially eligible for education become skilled workers, hence $H_t = Fr_t$ is satisfied. Since transfers from parents constrain available investment opportunities, this case is called the *unequal opportunity case*.

In the next period, the individual, given asset a_t^i and acquired ability (skilled or unskilled), determines the amount of transfer to the child b_{t+1}^i according to (7). By substituting the above investment rules into the transfer rule (7), the dynamic equation linking the received transfer b_t^i to the transfer given to the next generation b_{t+1}^i is derived.

If she is a skilled worker, i.e. $b_t^i \geq e$, the equation takes the following form:

$$b_{t+1}^i = \; b_s(b_t^i) \equiv (1 - \gamma_l - \gamma_h)\{w_H + (1+r)(b_t^i - e)\}. \tag{19}$$

The assumption $(1 - \gamma_l - \gamma_h)(1+r) < 1$ is made so that the fixed point for the equation $(b_s)^* \equiv \frac{1-\gamma_l-\gamma_h}{1-(1-\gamma_l-\gamma_h)(1+r)}[w_H - (1+r)e]$ exists.

For an unskilled worker, i.e. $b_t^i < e$, the equation becomes

$$b_{t+1}^i = b_u(b_t^i; Fr_t, B_t) \equiv (1 - \gamma_l - \gamma_h)\{w_L(Fr_t, B_t) + (1+r)b_t^i\}, \tag{20}$$

$$\text{where} \quad w_L(Fr_t, B_t) = \frac{\gamma_l}{1-\gamma_l}\frac{[w_H - (1+r)e]Fr_t + (1+r)B_t}{(1 - Fr_t)}. \tag{21}$$

The dynamic equation for an unskilled worker does depend on the aggregate variables $H_t = Fr_t$ and B_t, since they affect the relative price of good L and thus the unskilled wage. The fixed point of the equation for *given* Fr_t and B_t is denoted by $b_u^*(Fr_t, B_t) \equiv \frac{1-\gamma_l-\gamma_h}{1-(1-\gamma_l-\gamma_h)(1+r)} w_L(Fr_t, B_t)$.[14]

[14] In general, this is *not* the long-run transfer level of a lineage of a currently unskilled worker, since her descendants may become skilled workers *and* Fr_t and B_t may change over time. One might think that this fixed point does not have any economic importance, but it turns out that the level of $b_u^*(Fr_t, B_t)$ is crucial for aggregate dynamics (detailed

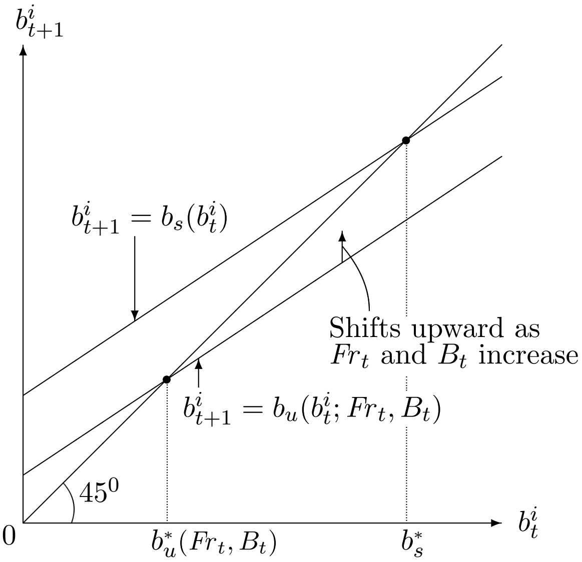

Figure 1: Individual dynamics of intergenerational transfers

The dynamics of intergenerational transfers of a currently skilled worker $b^i_{t+1} = b_s(b^i_t)$ and of a currently unskilled worker $b^i_{t+1} = b_u(b^i_t; Fr_t, B_t)$ for *given* Fr_t and B_t are depicted in Figure 1.[15] As long as $w_H - (1+r)e > w_L(Fr_t, B_t)$ is satisfied, $b^i_{t+1} = b_u(b^i_t; Fr_t, B_t)$ is located below $b^i_{t+1} = b_s(b^i_t)$, but it shifts upward with increases in Fr_t and B_t.

3.1.2 Equal opportunity case

Next consider the case in which many individuals can afford education so that the return from education *fails* to be higher than the return from assets, *if* all of them invest in education, i.e. $w_H - (1+r)e \leq w_L(Fr_t, B_t)$. In this situation, the number of skilled workers H_t is determined at the point where the two returns are equated, that is, H_t is the solution of $w_H - (1+r)e = w_L(H_t, B_t)$. Now *not* all of financially eligible individuals take education and become skilled workers, i.e. $H_t \leq Fr_t$. Since the return from the investments does *not* depend on transfers from parents, this case is named the *equal opportunity case*. Dynamics of transfers of both skilled and unskilled workers are described by $b^i_{t+1} = b_s(b^i_t)$, (19). In Figure 1, this is the situation in which $P(H_t, B_t)$ is high enough that $b^i_{t+1} = b_u(b^i_t; H_t, B_t)$ coincides with $b^i_{t+1} = b_s(b^i_t)$.

later).

[15] To be more precise, $b^i_{t+1} = b_s(b^i_t)$ is defined only for $b^i_t \geq e$ and $b^i_{t+1} = b_u(b^i_t)$ is only for $b^i_t < e$. However, since the location of e relative to $b^*_u(Fr_t, B_t)$ depends on Fr_t and B_t, e is not shown in the figure.

3.1.3 Dividing line

The economy belongs to either of the two cases depending on Fr_t and B_t. The combination of Fr_t and B_t satisfying $w_H - (1+r)e = w_L(Fr_t, B_t)$ is the dividing line, which is obtained by substituting $P_t = [w_H - (1+r)e]/A_L$, $\sum_i a_t^i = B_t - eH_t$, and $H_t = Fr_t$ into (13) and solving the equation for Fr_t,

$$Fr_t = H^e(B_t) \equiv (1-\gamma_l) - \frac{\gamma_l(1+r)B_t}{w_H - (1+r)e}. \tag{22}$$

The unequal opportunity case corresponds to $Fr_t < H^e(B_t)$, while the equal opportunity case amounts to $Fr_t \geq H^e(B_t) = H_t$.

3.2 Aggregate dynamics

What has become clear now is that the individual dynamics depend on the dynamics of two aggregate variables, aggregate transfers B_t and the fraction of individuals satisfying $b_t^i \geq e, Fr_t$. As mentioned above, information on the direction of motion of the two aggregate variables is enough to derive main implications of the model. Thus this subsection analyzes the dynamics of the two aggregate variables qualitatively. For exposition, first each of them is examined separately fixing the other variable, then their interaction is taken into account at the end.

3.2.1 Dynamics of aggregate transfers

Here the dynamics of aggregate intergenerational transfers B_t are examined for *given* Fr_t. First, consider the unequal opportunity case, i.e. $Fr_t < H^e(B_t)$. As seen in the previous subsection, $w_H - (1+r)e > w_L(H_t, B_t)$ and $H_t = Fr_t$ hold in this case. The dynamic equation of aggregate transfers B_{t+1} is given by the following equation, which is derived by aggregating individual dynamics of skilled (19) and of unskilled workers (20) over the population and substituting $H_t = Fr_t$:

$$B_{t+1} = B(Fr_t, B_t) \equiv \frac{1-\gamma_l-\gamma_h}{1-\gamma_l}\{[w_H - (1+r)e]Fr_t + (1+r)B_t\}. \tag{23}$$

The assumption $\frac{1-\gamma_l-\gamma_h}{1-\gamma_l}(1+r) < 1$ is made so that there exists a fixed point for the equation given Fr_t, where the fixed point $B^*(Fr_t)$ is equal to

$$B^*(Fr_t) \equiv \frac{1}{1-\frac{1-\gamma_l-\gamma_h}{1-\gamma_l}(1+r)} \frac{1-\gamma_l-\gamma_h}{1-\gamma_l}[w_H - (1+r)e]Fr_t. \tag{24}$$

Alternatively, in the equal opportunity case ($Fr_t \geq H^e(B_t)$), $w_H - (1+r)e = w_L(H_t, B_t)$, i.e. $H_t = H^e(B_t)$, holds in an equilibrium. In this case the dynamic equation is obtained by substituting $H_t = H^e(B_t)$ into $B_{t+1} = B(H_t, B_t)$:

$$B_{t+1} = B(H^e(B_t), B_t) \equiv (1 - \gamma_l - \gamma_h)\{[w_H - (1+r)e] + (1+r)B_t\}. \tag{25}$$

Note that the equation does not depend on Fr_t. The fixed point of this equation B^{**} is

$$B^{**} = \tfrac{1-\gamma_l-\gamma_h}{1-(1-\gamma_l-\gamma_h)(1+r)}[w_H - (1+r)e], \tag{26}$$

which is equal to $(b_s)^*$. The number of skilled workers at B^{**}, $H^{**} \equiv H^e(B^{**})$, is equal to

$$\begin{aligned} H^{**} \equiv H^e(B^{**}) &= (1-\gamma_l) - \frac{\gamma_l(1+r)B^{**}}{[w_H - (1+r)e]}, \\ &= 1 - \frac{\gamma_l}{1-(1-\gamma_l-\gamma_h)(1+r)}. \end{aligned} \tag{27}$$

3.2.2 Dynamics of Fr_t

Next the dynamics of Fr_t, the proportion of people who can afford to take education, are examined for *given* B_t. Unlike aggregate transfers, the dynamic equation relating Fr_t to Fr_{t+1} depends on the distribution of transfers over the population, so it cannot be derived without complete information on the distribution. However, the direction of change of Fr_t *can* be known only with current values of the two aggregate variables, B_t and Fr_t.

Assume that $(1-\gamma_l-\gamma_h)w_H \geq e$, i.e. $B^{**} = b_s^* \geq e$, is satisfied.[16] Then, Fr_t is *non-decreasing* over time, since $b_{t+1}^i \geq e$ is satisfied whenever $b_t^i \geq e$ is true (see Figure 2).

First, consider the unequal opportunity case, in which transfers of unskilled workers change over time according to $b_{t+1}^i = b_u(b_t^i; Fr_t, B_t)$. Whether Fr_t remains constant or increases is determined by the relative size of $b_u^*(Fr_t, B_t)$ to e. When $b_u^*(:) < e$, none of offspring of currently unskilled workers receive transfers greater than e, so Fr_t is constant (see Figure 2). In contrast, when $b_u^*(:) \geq e$ is satisfied, $Fr_{t+1} \geq Fr_t$ holds, since education becomes affordable to children of unskilled

[16] Note that this assumption does *not* place any restrictions on the productivity of sector H. Since $e = s_e w_H$, the assumption can be rewritten as $1 - \gamma_l - \gamma_h \geq s_e$. What this condition implies is that people are altruistic enough towards their children.

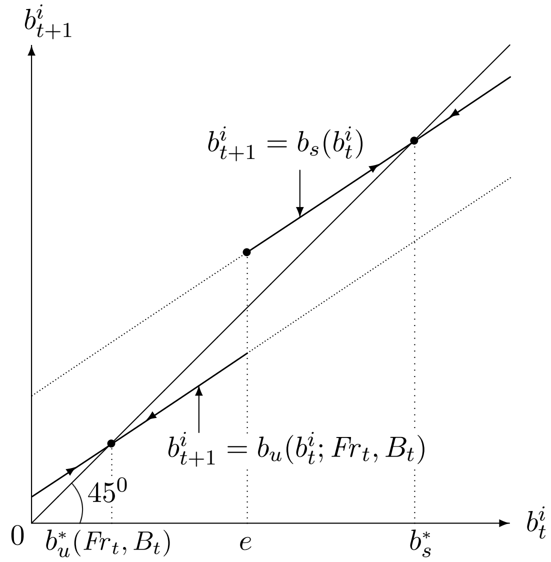

Figure 2: Unequal opportunity case when $b^*_u(Fr_t, B_t) < e$

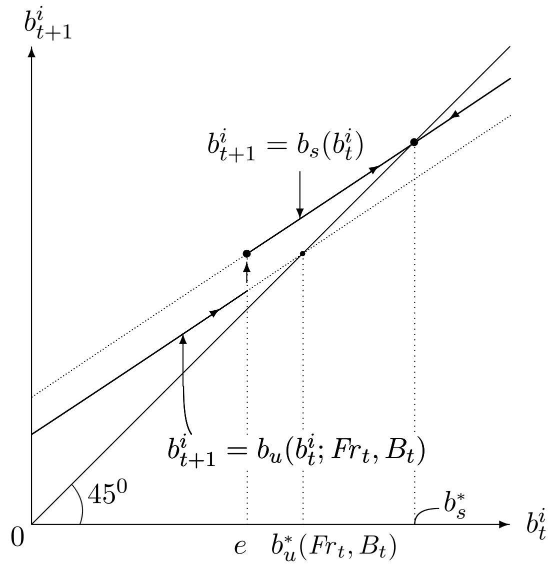

Figure 3: Unequal opportunity case when $b^*_u(Fr_t, B_t) \geq e$

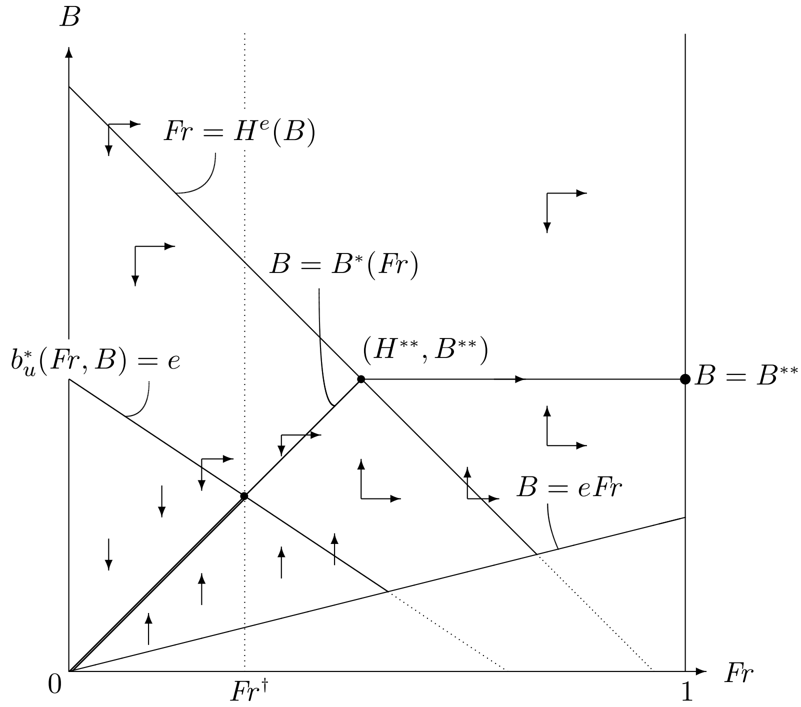

Figure 4: Phase diagram

workers over time (see Figure 3). From (21), the dividing line $b_u^*(Fr_t, B_t) = e$ is given by

$$B_t = \frac{1-(1-\gamma_l-\gamma_h)(1+r)}{(1-\gamma_l-\gamma_h)(1+r)}\frac{1-\gamma_l}{\gamma_l}e(1-Fr_t) - \frac{[w_H-(1+r)e]Fr_t}{1+r}. \tag{28}$$

Alternatively, in the equal opportunity case, transfers of both skilled and unskilled workers follow $b_{t+1}^i = b_s(b_t^i)$, and $Fr_{t+1} \geq Fr_t$ is satisfied.

3.2.3 Joint dynamics of Fr_t and B_t

Now the dynamics of Fr_t and B_t are analyzed together by introducing the phase diagram (Figure 4), in which the horizontal axis represents Fr and the vertical axis represents B. Feasible combinations of Fr and B are equal to the area bound by $Fr = 0$, $Fr = 1$, and $B = eFr$. The economy must satisfy $B \geq eFr$ because Fr is defined as the fraction of individuals who have received transfers b^i larger than the cost of education e.

The diagram is divided into two regions, one corresponding to the unequal opportunity case and the other region for the equal opportunity case. The locus dividing the two cases is $Fr = H^e(B)$, (22). The region below the locus is the unequal opportunity case, where all the individuals who can afford education take education and become skilled workers, i.e. $H = Fr$. The region above it is the equal opportunity case, in which the number of skilled workers is determined so that the return from education is equated with the return from assets, i.e. $H = H^e(B) \leq Fr$.

In the unequal opportunity case, the direction of motion of B is determined by the position of current (Fr_t, B_t) relative to $B = B^*(Fr)$, (24). When the current economy is located on the line, B_t is constant; when located above (below), it decreases (increases) over time. The direction of change of B in each region is expressed with vertical arrows. As for the direction of change of $Fr = H$, it is determined by the location of (Fr_t, B_t) relative to $b_u^*(Fr, B) = e$. In the region below the line, $b_u^*(:) < e$ is satisfied, accordingly $Fr_{t+1} = Fr_t$ holds; in the region on or above the line, $b_u^*(:) \geq e$, hence $Fr_{t+1} \geq Fr_t$ is satisfied. Alternatively, in the equal opportunity case, the direction of motion of B is determined by the relative location to $B = B^{**}$, (26), and $Fr_{t+1} \geq Fr_t$ is always satisfied.

With this diagram, qualitative properties of transitional dynamics and the long-run outcome of the aggregate variables (Fr, B) are transparent. Except when $B > B^*(Fr)$, $b_u^*(Fr, B) > e$, and $Fr < H^{**}$ are simultaneously satisfied, they are completely known only with the position of (Fr_t, B_t) in the diagram.

4 Analyses

4.1 Initial distribution and long-run economic structure

By using this diagram, the relationship between the initial distribution of wealth and the long-run structure of the economy along with its transition can be easily investigated.

First, consider an economy that attains equal opportunity from the beginning, whose initial position is in the region on or above $Fr = H^e(B)$ in the diagram. Since the returns from the two investment opportunities are equated, both skilled and unskilled workers earn the same level of earnings (*net* of the cost of education), and education become affordable to children of unskilled workers over time (Fr increases). The result is that, when the economy starts with $Fr_0 \geq Fr^\dagger$ ($Fr^\dagger$ is defined as the value of Fr at the intersection of $b_u^*(Fr, B) = e$ and $B = B^*(Fr)$), it converges to $(Fr, B) = (1, B^{**})$ for certain, where not only the net earnings but also net income and wealth are equalized and $b^i = b_s^*$ holds. That is, *perfect equality* is attained. The long-run outcome of the economy with the initial condition $Fr_0 < Fr^\dagger$ depends on the exact initial distribution. If wealth is highly concentrated in the rich, Fr would increase only slightly and the economy would regress to the unequal opportunity case (crosses the line $Fr = H^e(B_t)$). Otherwise, it would converge to $(1, B^{**})$ in the long run.

Next examine an economy that starts from the area below $Fr = H^e(B)$ and on or above $b_u^*(Fr_t, B) = e$. This economy does not satisfy equal opportunity initially, but children of unskilled workers gain access to education over time (Fr increases). Thus the number of skilled workers increases and wage inequality between skilled and unskilled workers diminishes. Associated with this change, production and employment shares of sector H rise, while those of sector L fall. When $Fr_0 \geq Fr^\dagger$, the economy reaches the equal opportunity case eventually and perfect equality is attained in the long run. On the other hand, when $Fr_0 < Fr^\dagger$, the long-run outcome depends on the exact initial distribution. If the distribution is concentrated in the few rich, then the number of skilled workers increases only slightly over time, and it is possible that the economy crosses $b_u^*(:) = e$.

The remaining scenario is that an economy starts from the area below $b_u^*(Fr_t, B) = e$, where not only investment opportunities are unequal but also children of unskilled workers cannot access education, i.e. $b_u^*(:) < e$. Since the number of skilled workers does not increase, production and employment shares of the sectors remain constant. In particular, if the initial condition is $Fr_0 < Fr^\dagger$, the economy converges to $(Fr_0, B^*(Fr_0))$, and *unequal opportunity and inequality persist* in the long run. If the economy begins with $Fr_0 \geq Fr^\dagger$, its long-run prospect is much brighter. While its asset accumulation is low, poor people cannot afford education and hence the number of skilled workers remains constant. But, after a certain amount of asset accumulation, the economy transits to $b_u^*(:) \geq e$ and the sectoral shift starts. In the long run, it attains equal opportunity and perfect equality of earnings and wealth.

The analysis has shown that there is a clear-cut relationship between the initial distribution of wealth and the attainment of the structural change and equal opportunity in the long run. That is, if the initial distribution is such that the fraction of individuals who have enough resources to take education is low, the economy remains stagnant. Thus, a size of 'middle class' of an economy matters for development through sectoral change. Note that equal distribution does not always lead to development: if initial aggregate wealth is very low, too equal wealth distribution implies $Fr_0 < Fr^\dagger$ and results in stagnation. Further, if an economy starts below the critical level of asset accumulation, $B_0 = Fr^\dagger e$, it remains stagnant irrespective of initial distribution.

4.2 Comparisons among long-run equilibria

There are two kinds of steady state equilibria, $(Fr_{ss}, B_{ss}) = (1, B^{**})$ and $(Fr, B^*(Fr))$, where $Fr < Fr^\dagger$. In the former equilibrium, the number of skilled workers is H^{**}, the skilled wage (net of the cost of education) is equal to the unskilled wage, and all individuals hold the same level of wealth, $\frac{1}{1-\gamma_l-\gamma_h}(b_s)^*$.[17] On the other hand, in the latter type of equilibria, the number of skilled workers is Fr $(< Fr^\dagger < H^{**})$, the skilled wage is higher than unskilled wage, and the wealth of skilled workers $\frac{1}{1-\gamma_l-\gamma_h}(b_s)^*$ is larger than that of unskilled workers $\frac{1}{1-\gamma_l-\gamma_h}b_u^*(Fr, B^*(Fr))$. The relative price of good L, $P(H, B^*(H))$, is increasing in H, so are $w_L(H, B^*(H))$ and $b_u^*(H, B^*(H))$. These steady state equilibria can be ranked in terms of the wage and wealth of unskilled workers, which can be interpreted as measures of inequality between skilled and unskilled workers,[18] and the total wealth of the economy.[19] The best equilibrium is $(1, B^{**})$, then among equilibria $(Fr, B^*(Fr))$, $Fr < Fr^\dagger$, one with larger Fr is better.

Note that wages and wealth are measured in terms of good H, but the relative price of good L is different across the equilibria. For accurate welfare comparisons, the utility of each type of individuals is computed. At equilibrium $(1, B^{**})$, both skilled and unskilled workers have the same utility level,

$$U(1, B^{**}) = \frac{\gamma_l^{\gamma_l}\gamma_h^{\gamma_h}(1-\gamma_l-\gamma_h)^{1-\gamma_l-\gamma_h}}{1-(1-\gamma_l-\gamma_h)(1+r)}(A_L)^{\gamma_l}[w_H - (1+r)e]^{1-\gamma_l}. \tag{29}$$

At equilibria $(Fr, B^*(Fr))$, $Fr < Fr^\dagger$, the utility of skilled workers is given by

$$U_s(Fr, B^*(Fr)) = U(1, B^{**}) \cdot \big(\frac{1-H^{**}}{H^{**}}\frac{Fr}{1-Fr}\big)^{-\gamma_l}. \tag{30}$$

$U_s(Fr, B^*(Fr)) > U(1, B^{**})$ is satisfied since $Fr < H^{**}$. Skilled workers have higher utilities than at equilibrium $(1, B^{**})$ because good L is cheaper. In contrast, unskilled workers have lower utilities than at $(1, B^{**})$:

$$U_u(Fr, B^*(Fr)) = U(1, B^{**}) \cdot \big(\frac{1-H^{**}}{H^{**}}\frac{Fr}{1-Fr}\big)^{1-\gamma_l}. \tag{31}$$

[17] Wealth is defined as $w_H - (1+r)e + (1+r)(b_s)^*$.

[18] Remember that the wage and wealth of skilled workers are the same in all the steady state equilibria. Interestingly, Deininger and Squire (1998) finds that initial land and income inequality affect negatively income growth of the poor, but *not* of the rich.

[19] Total wealth at equilibrium $(1, B^{**})$ is equal to $\frac{1}{1-\gamma_l-\gamma_h}(b_s)^*$, while at equilibria $(Fr, B^*(Fr))$, $Fr < Fr^\dagger$, it is equal to $\frac{1}{1-\gamma_l-\gamma_h}(b_s)^*\frac{Fr}{H^{**}}$.

Note that $U_s(Fr, B^*(Fr))$ is decreasing and $U_u(Fr, B^*(Fr))$ is increasing in Fr, so inequality in welfare decreases with Fr. The average utility, which can be interpreted as the expected utility of an individual before birth, is given by the following expression:

$$E[U(H, B^*(H))] = U(1, B^{**}) \cdot \big(\frac{H}{H^{**}}\big)^{1-\gamma_l} \big(\frac{1-H}{1-H^{**}}\big)^{\gamma_l}. \tag{32}$$

The average utility is strictly increasing in H and attains the highest value at $H = H^{**}$ since $H \leq H^{**} < 1 - \gamma_l$. Thus, the ranking among the steady state equilibria remains unchanged if the average utility is used for the comparison.

4.3 Mechanism behind the model

The mechanism of the model yielding the above results can be explained intuitively by the following illustration (see Figure 4). Consider an economy in which skilled workers are scarce ($H_0 = Fr_0 < H^{**}$) and its asset accumulation is modest ($B_0 < B^*(H_0)$) initially. How can this economy achieve higher income level? One route is through further asset accumulation. This is possible since people, starting with small amounts of assets, increase asset holdings over time. The higher wealth raises the demand for good L, its price, and the unskilled wage. The increased unskilled wage then stimulates savings by unskilled workers, further promoting asset accumulation. This process continues until aggregate assets reach the steady state level. However, with the number of skilled workers constant, the income increase is moderate since the ultimate source of asset accumulation is labor income. Further, inequality between skilled and unskilled workers remains large because the investment opportunities are constrained by family income.

Thus, in order to attain large income growth, *an increase in the number of skilled workers and the sectoral shift* of production and employment from sector L to sector H is crucial. The sectoral shift starts iff a fraction of children of unskilled workers receive enough resources to take education, which is possible when the unskilled wage $w_{L,t} = P_t A_L$ and thus the relative price of good L are above critical levels. The relative price depends positively on the number of skilled workers and aggregate assets: the demand for good L increases with the both variables, while the supply decreases with the number of skilled workers. Hence the two variables must be above certain levels for the 'take-off', i.e. $b_u^*(Fr, B) \geq e$.

When the economy begins with a initial wealth distribution satisfying $Fr_0 \geq Fr^\dagger$, the relative price of good L and the unskilled wage are relatively high. If the combination of Fr_0 and B_0 satisfies $b_u^*(Fr_0, B_0) \geq e$, then a wealthier portion of unskilled workers can send their children to school and the sectoral shift starts immediately. If not, children of unskilled workers cannot access education initially. However, as asset accumulation continues, the relative price eventually reaches the crucial level and the economy 'take offs'. Once the sectoral shift starts, it continues autonomously. An increase in the number of skilled workers and the resulting asset accumulation raise the demand for good L and reduces its supply, contributing to further rises in the price of good L and the unskilled wage. Accordingly, children of less affluent unskilled workers gain access to education and the number of skilled workers increases further, which raises the unskilled wage more and even a poorer segment of unskilled workers can get their children to take education. As long as the skilled wage (net of the cost of education) is higher than the unskilled wage, financially eligible children take education and become skilled workers. This process continues until the relative price of good L increases to a point where net wages of skilled and unskilled workers are equated.[20] Once equal opportunity is attained, the unskilled wage does not change, but the size of 'middle class' and aggregate transfers continue to increase until they reach the steady state levels, $(Fr_{ss}, B_{ss}) = (1, B^{**})$.

In contrast, when the economy starts with a asset distribution satisfying $Fr_0 < Fr^{\dagger}$, the initial number of skilled workers is small and the unskilled wage is low. Children of unskilled workers are not financially eligible for education and cannot become skilled workers. Still, the relative wage increases over time through asset accumulation but never reaches the critical level for the sectoral shift. With the number of skilled workers constant, inequality between skilled and unskilled workers does not disappear, and the economy ends up with the equilibria with lower output and less equal distribution, $(Fr_{ss}, B_{ss}) = (Fr, B^*(Fr))$, $Fr < Fr^{\dagger}$.

When initial asset accumulation is relatively large for the number of skilled workers ($B_0 > B^*(H_0)$), the relative price of good L and the unskilled wage are higher, thus the sectoral shift occurs more easily. However, unless $Fr_0 \geq Fr^{\dagger}$, the convergence to the best steady state is not assured. This is because the ultimate source of asset accumulation is labor income. Since initial asset accumulation exceeds the level that labor income can support in the long run, there is a tendency for assets to decrease over time. If wealth is concentrated in the few rich and the number

[20] Psacharopoulos (1989, 1994) show that returns to education are higher in low-income nations especially at primary and secondary education levels.

of skilled workers increases only moderately, asset accumulation does decrease over time and the economy converges to an unequal steady state.

4.4 Productivity growth

Now productivity growth is introduced into the model to see if the results are robust to this modification. Assume that the productivity of sector L increases at a constant rate of g_L and that of sector H grows steadily at g_H. With the given constant interest rate r, the skilled wage now grows at $(g_H)^{\frac{1}{\alpha}}$ and the unskilled wage grows at $g_L + g_{P,t}$, where $g_{P,t}$ is the period t growth rate of the relative price.

Individual's investment decisions follow the same rules as the fixed productivity model, but now that the wages grow over time, the cost of education also grows ($e_t = s_e w_{H,t-1}$). All the equations describing the individual and aggregate dynamics are same as before. The difference is that there are no fixed points for the dynamic equations because of the productivity growth. However, by dividing both sides of the equations by $\{(g_H)^{\frac{1}{\alpha}}\}^t$ and redefining the variables accordingly, the modified dynamics can be analyzed in a similar way as before.[21] For the modified dynamics, the qualitatively same phase diagram can be drawn, hence all the results go through.[22]

Because of the productivity growth, all the (original) variables except Fr grow over time in the long run: the wages, the individual and aggregate assets all grow at rate $(g_H)^{\frac{1}{\alpha}}$ and the relative price of good L grows at $(g_H)^{\frac{1}{\alpha}}/g_L$. Without the productivity growth, the sectoral shift is necessarily associated with a rise of the relative price of good L, but now the relative price may *decrease* over time if g_L is large enough.

[21] The variables are redefined as follows:

$$\begin{aligned} w_H &\equiv w_{H,t}/\{(g_H)^{\frac{1}{\alpha}}\}^t, \\ e &\equiv e_t/\{(g_H)^{\frac{1}{\alpha}}\}^{t-1}, \\ b_t^i &\equiv b_t^i/\{(g_H)^{\frac{1}{\alpha}}\}^{t-1}, \\ B_t &\equiv B_t/\{(g_H)^{\frac{1}{\alpha}}\}^{t-1}, \\ \text{and } P(H_t, B_t) &\equiv P(H_t, B_t)/\{(g_H)^{\frac{1}{\alpha}}\}^t. \end{aligned}$$

The modified dynamic equations for the model with productivity growth are different from the respective equations for the model with constant productivity only in one respect: $1+r$ in the latter model must be replaced by $(1+r)/(g_H)^{\frac{1}{\alpha}}$.

[22] One thing to note is that both the number of skilled workers in the equal opportunity case, H^{**}, and the critical size of 'middle class' for the 'take-off', $Fr^{\dagger}$, increase with the productivity growth rate of sector H, g_H. That is, with the faster productivity growth, an economy in equal opportunity can hold more skilled workers and thus greater sector H, but it becomes more difficult for an economy with a small size of 'middle class' to initiate the sectoral shift.

5 Introducing the sectoral shift of consumption

The analysis so far has employed the Cobb-Douglas utility function, and hence has abstracted from the sectoral shift of consumption from the traditional sector (sector L) to the modern sector (sector H). It is a stylized fact that consumers spend more of their incomes on skill intensive goods and transfers as their income levels go up (see, for example, Syrquin, 1988, for the evidence). In this section, the utility function is modified so that this feature can be observed in the model. After this modification, *the productivity of sector L* as well as initial wealth distribution become determinants of the long-run structure of the economy. In particular, it is shown that if an economy's productivity of sector L is sufficiently low, it ends up in a steady state with low output and high inequality *regardless of* its initial wealth distribution and the productivity level of the modern sector.

5.1 Model

5.1.1 Individual decisions and price determination

The modified utility function takes the following form:

$$U_t^i = (c_{L,t}^i - \widetilde{c_L})^{\gamma_l} (c_{H,t}^i)^{\gamma_h} (b_{t+1}^i)^{1-\gamma_l-\gamma_h}. \tag{33}$$

The constant $\widetilde{c_L}$ may be interpreted as the minimum consumption level of good L needed for subsistence, when good L is interpreted as agricultural goods produced with traditional technology. A consumer maximizes the new utility subject to the budget constraint,

$$P_t c_{L,t}^i + c_{H,t}^i + b_{t+1}^i = w_t^i + (1+r)a_t^i, \tag{34}$$

where w_t^i is earnings and a_t^i is the investment in assets made in the previous period (childhood).

By solving the maximization problem, the following consumption and transfer rules are obtained:

$$P_t c_{L,t}^i = \gamma_l [w_t^i + (1+r)a_t^i] + (1-\gamma_l) P_t \widetilde{c_L}, \tag{35}$$

$$c_{H,t}^i = \gamma_h [w_t^i + (1+r)a_t^i - P_t \widetilde{c_L}], \tag{36}$$

$$\text{and} \quad b_{t+1}^i = (1-\gamma_l-\gamma_h)[w_t^i + (1+r)a_t^i - P_t \widetilde{c_L}]. \tag{37}$$

The consumer first spends the wealth $w_t^i + (1+r)a_t^i$ to purchase the subsistence level of good L,

$P_t\widetilde{c_L}$, then allocates the rest of the wealth to the goods and transfer in fixed proportions. As income grows, the share of the wealth spent on good L decreases and the shares spent on good H and the transfer increase, if P_t does not grow faster than the wealth. The price elasticity of good L is smaller than one, while those of good H and the transfer are larger than one.

The model is presented assuming constant productivities. Since the market structure is the same as before, the wages of skilled and unskilled workers are given by the same equations, $w_H = \alpha(A_H)^{\frac{1}{\alpha}}\left(\frac{1-\alpha}{r}\right)^{\frac{1}{\alpha}-1}$ and $w_{L,t} = P_t A_L$.

The market clearing condition of good L is different from the one in the previous model because of the term associated with $\widetilde{c_L}$:

$$P_t A_L L_t = \gamma_l \Big[w_{L,t} L_t + w_H H_t + (1+r) \sum_i a_t^i \Big] + (1-\gamma_l) P_t \widetilde{c_L}. \tag{38}$$

Remember that L_t is the number of unskilled workers, H_t is the number of skilled workers, and $\sum_i a_t^i$ is aggregate assets. Substituting $w_{L,t} = P_t A_L$, $L_t = 1 - H_t$, and $\sum_i a_t^i = B_t - eH_t$ into the above equation, and solving it for P_t, the relative price of good L is given by

$$P_t = P(H_t, B_t) \equiv \frac{\gamma_l}{1-\gamma_l} \frac{[w_H - (1+r)e]H_t + (1+r)B_t}{A_L(1-H_t) - \widetilde{c_L}}. \tag{39}$$

It is assumed that the productivity of sector L is high enough ($A_L > \widetilde{c_L}$) that the economy can support at least the subsistence level of consumption $\widetilde{c_L}$, if the whole population is in sector L. With the presence of $\widetilde{c_L}$, higher productivity A_L lowers P_t *more than proportionally*, because people start spending smaller portions of their incomes on good L.

5.1.2 Individual dynamics

In the unequal opportunity case, i.e. $w_H - (1+r)e > w_L(Fr_t, B_t)$, transfers of skilled workers are governed by the following equation, which is obtained by substituting $w_t^i = w_H$, $a_t^i = b_t^i - e$, and $H_t = Fr_t$ into (37):

$$b_{t+1}^i = \; b_s(b_t^i; Fr_t, B_t) \equiv (1-\gamma_l-\gamma_h)\{[w_H - (1+r)e] + (1+r)b_t^i - P(Fr_t, B_t)\widetilde{c_L}\}. \tag{40}$$

Now the equation depends *negatively* on Fr_t and aggregate transfers B_t through P_t. Increases in Fr_t and B_t raise the price of good L, forcing individuals to increase spendings on the subsistence level of the good and reduce transfers. The fixed point of the equation for given $P(Fr_t, B_t)$, $b_s^*(Fr_t, B_t)$, is equal to

$$b_s^*(Fr_t, B_t) \equiv \tfrac{1-\gamma_l-\gamma_h}{1-(1-\gamma_l-\gamma_h)(1+r)}\{[w_H - (1+r)e] - P(Fr_t, B_t)\widetilde{c_L}\}. \tag{41}$$

As for unskilled workers, the dynamics of transfers are governed by the following equation, which is obtained by plugging $w_t^i = A_L P(Fr_t, B_t)$, $a_t^i = b_t^i$, and $H_t = Fr_t$ into (37):

$$b_{t+1}^i = b_u^i(b_t^i; Fr_t, B_t) \equiv (1-\gamma_l-\gamma_h)\{(1+r)b_t^i + (A_L - \widetilde{c_L})P(Fr_t, B_t)\}. \tag{42}$$

The dynamic equation for unskilled workers depends *positively* on Fr_t and B_t through P_t, since the effect of the good L price on their earnings exceeds the effect on the expenditure on the subsistence level of good L. The fixed point for given $P(Fr_t, B_t)$, $b_u^*(Fr_t, B_t)$, is equal to

$$b_u^*(Fr_t, B_t) \equiv \tfrac{1-\gamma_l-\gamma_h}{1-(1-\gamma_l-\gamma_h)(1+r)}(A_L - \widetilde{c_L})P(Fr_t, B_t). \tag{43}$$

In the equal opportunity case, i.e. $w_H - (1+r)e \le w_L(Fr_t, B_t)$, transfers of both types of workers follow

$$b_{t+1}^i = b(b_t^i) \equiv (1-\gamma_l-\gamma_h)\big\{(1+r)b_t^i + [w_H - (1+r)e]\big(1 - \frac{\widetilde{c_L}}{A_L}\big)\big\}. \tag{44}$$

The equation is obtained from the substitution of $P(H_t, B_t) = [w_H - (1+r)e]/A_L$ into (42). The fixed point of the equation, b^*, is

$$b^* \equiv \tfrac{1-\gamma_l-\gamma_h}{1-(1-\gamma_l-\gamma_h)(1+r)}[w_H - (1+r)e]\big(1 - \frac{\widetilde{c_L}}{A_L}\big). \tag{45}$$

Combinations of Fr_t and B_t satisfying $w_H - (1+r)e = w_L(Fr_t, B_t)$ separate the two cases. The dividing line is obtained by substituting $P_t = [w_H - (1+r)e]/A_L$ and $H_t = Fr_t$ into (39) and solving the equation for Fr_t:

$$Fr_t = H^e(B_t) \equiv (1-\gamma_l)\big(1 - \frac{\widetilde{c_L}}{A_L}\big) - \frac{\gamma_l(1+r)B_t}{[w_H - (1+r)e]}. \tag{46}$$

5.1.3 Dynamics of aggregate transfers

In the unequal opportunity case, the dynamics of aggregate transfers B_t follow the same equation as before:

$$B_{t+1} = B(Fr_t, B_t) \equiv \frac{1-\gamma_l-\gamma_h}{1-\gamma_l}\{[w_H - (1+r)e]Fr_t + (1+r)B_t\}. \tag{47}$$

The fixed point of the equation for given Fr_t is equal to $B^*(Fr_t) \equiv [1 - \frac{1-\gamma_l-\gamma_h}{1-\gamma_l}(1+r)]^{-1} \times \frac{1-\gamma_l-\gamma_h}{1-\gamma_l}[w_H - (1+r)e]Fr_t$.

In the equal opportunity case, the dynamics are described by $B_{t+1} = B(H^e(B_t), B_t)$, which is obtained by plugging $H_t = H^e(B_t)$ into $B_t = B(H_t, B_t)$:

$$B_{t+1} = B(H^e(B_t), B_t) \equiv (1-\gamma_l-\gamma_h)\big\{[w_H - (1+r)e]\big(1 - \frac{\widetilde{c_L}}{A_L}\big) + (1+r)B_t\big\}. \tag{48}$$

The fixed point of this equation B^{**} is given by

$$B^{**} \equiv \tfrac{1-\gamma_l-\gamma_h}{1-(1-\gamma_l-\gamma_h)(1+r)}[w_H - (1+r)e]\big(1 - \frac{\widetilde{c_L}}{A_L}\big), \tag{49}$$

which is equal to b^*. The number of skilled workers at B^{**}, $H^{**} \equiv H(B^{**})$, is

$$H^{**} \equiv H(B^{**}) = \big[1 - \tfrac{\gamma_l}{1-(1-\gamma_L-\gamma_h)(1+r)}\big]\big(1 - \frac{\widetilde{c_L}}{A_L}\big). \tag{50}$$

5.1.4 Joint dynamics of Fr_t and B_t

As before, the joint dynamics of Fr_t and B_t, and relationship between initial wealth distribution and the long-run performance of an economy are investigated using a phase diagram.

High productivity in sector L: When the productivity of sector L is large enough that $A_L[(1-\gamma_l-\gamma_h)w_H - e] > (1-\gamma_l-\gamma_h)[w_H - (1+r)e]\widetilde{c_L}$, or $A_L(1-\gamma_l-\gamma_h-s_e) > (1-\gamma_l-\gamma_h)[1-(1+r)s_e]\widetilde{c_L}$ is satisfied, the phase diagram looks like the one in Section 3 (Figure 4).[23] The qualitative nature of the dynamics remains unchanged in this case. That is, when the economy starts with a relatively equal wealth distribution with sufficient aggregate wealth, it converges to $(Fr, B) = (1, B^{**})$, where perfect equality is achieved; when the economy begins with an unequal wealth distribution or too small aggregate wealth, it converges to one of $(Fr, B) = (Fr, B^*(Fr))$, $Fr < Fr^\dagger$, where the return from education is higher than that from assets, consequently inequality between skilled and unskilled workers is persistent.

[23]There are two minor differences from the economy without the sectoral shift of consumption. First, $Fr = H^e(B)$ shifts inwards by factor $(1 - \frac{\widetilde{c_L}}{A_L})$. Second, the slope of $b_u^*(Fr, B) = e$ becomes steeper by the presence of $(1 - \frac{\widetilde{c_L}}{A_L})$.

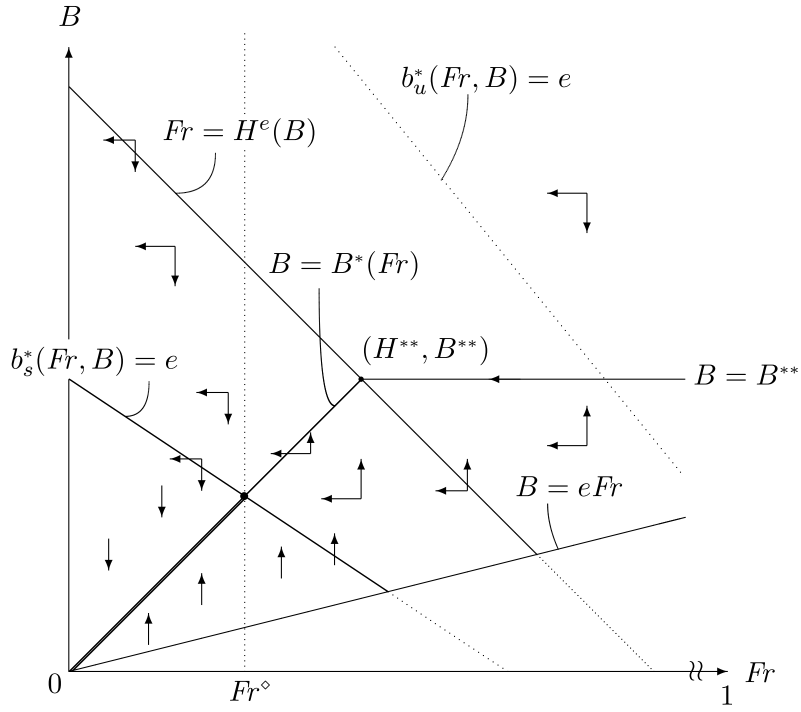

Figure 5: Economy with the sectoral shift of consumption: low productivity in sector L

Low productivity in sector L: On the other hand, when $A_L(1-\gamma_l-\gamma_h-s_e) < (1-\gamma_l-\gamma_h)[1-(1+r)s_e]\widetilde{c_L}$ is satisfied, that is, when the productivity of sector L is low, the phase diagram looks like Figure 5. Unlike the previous case, $b_u^*(Fr,B)=e$ is located *above* $Fr = H^e(B)$, hence $b_u^*(H,B) < e$ is satisfied for all the feasible combinations of (H,B),[24] while $b_s^*(Fr,B)=e$ is located *below* $Fr = H^e(B)$.[25] Consequently, descendants of unskilled workers *never* accumulate enough assets to become skilled workers. Since $b_s^*(Fr,B)$ is decreasing in Fr and B, in the region *above* $b_s^*(Fr,B)=e$, $b_s^*(:) < e$ is satisfied and $Fr_{t+1} \le Fr_t$ holds, while in the region *below* or on the line, $b_s^*(:) \ge e$ and $Fr_{t+1} = Fr_t$ hold. In the diagram, the value of Fr at the intersection of $B = B^*(Fr)$ and $b_s^*(Fr,B)=e$ is denoted by $Fr^\diamond$.

Using this diagram, relationship between initial wealth distribution and an economy's long-run outcome is examined. The most notable difference from the results of the model with the productive L sector or without the sectoral shift of consumption is that equal opportunity and perfect equality are *not* sustained in the long run. In the equal opportunity case, that is, in the region on or above $Fr = H^e(B)$ in the diagram, $b^* < e$ holds, so the proportion of individuals financially qualified for

[24] The condition on the productivity is equivalent to $b^* < e$. As a result, in the equal opportunity case, $b_u^*(H,B) = b_u^*(H^e(B),B) = b^* < e$ is satisfied. Then, $b_u^*(H,B) < e$ is satisfied for the unequal opportunity case as well, since $b_u^*(H,B) = b_u^*(Fr,B) < b_u^*(H^e(B),B)$.

[25] This is equivalent to $B^{**} = b^* < e$. So $B = eFr$ intersects with $B = B^{**}$ at $Fr < 1$ in this case.

education decreases over time. Consequently, the economy transits to the unequal opportunity case eventually. In the unequal opportunity case, as long as the economy is located above $b^*_s(Fr, B) = e$, the number of skilled workers decreases over time. Thus, the long-run equilibria of the economy are $(Fr, B) = (Fr, B^*(Fr))$, $Fr \leq Fr^\diamond$, where the (net) skilled wage is higher than the unskilled wage and unequal opportunity persists. Among the steady state equilibria, one with larger Fr achieves higher equality between skilled and unskilled workers and higher total income.

5.2 Analyses

With the introduction of the sectoral shift of consumption, the long-run outcome of the economy becomes dependent on the productivity of sector L. Why does sectoral shift not succeed when the productivity of the traditional sector is low? The requirement for the structural change is sizable wealth accumulation by a portion of unskilled workers so that they can send their children to school. How does the lower productivity affect their transfers? Remember that they have to consume at least $\widetilde{c_L}$ units of good L *irrespective* of its price, so the price elasticity of demand for the good is less than one. Accordingly, when the productivity of sector L is lower, the price of good L rises more than proportionally, thus the unskilled wage *goes up* as well, other things being equal. The higher wage allows unskilled workers to spend more on transfers, while the price increase forces them to raise the expenditure on good L. It turns out that the former effect dominates and transfers *increase*: now smaller 'middle class' and asset accumulation are sufficient for the sectoral shift to happen, i.e. $b^*_u(Fr, B) = e$ is located closer to the origin in the phase diagram. However, there is the other effect associated with the lower productivity and the resultant higher unskilled wage: because of the fall of return to education for given Fr and B, the economy can sustain less skilled labor and aggregate assets under equal opportunity, i.e. $Fr = H^e(B)$ is closer to the origin. If the productivity of sector L is low enough, as in Figure 5, the second effect dominates the first effect, i.e. $b^*_u(Fr, B) = e$ is located above $Fr = H^e(B)$, hence the sectoral shift never starts.

Further, the economy cannot maintain an initial condition with sizable skilled labor ($Fr_0 > Fr^\diamond$), because the price of good L is too high for all of current skilled workers to maintain transfers sufficient for education. The number of skilled workers must decline until the price level falls enough that they can sustain the needed transfers. In particular, the case where the economy starts with $Fr_0 > Fr^\diamond$ and $b^*_s(Fr_0, B_0) > e$ (the region below $b^*_s(Fr, B) = e$) is worth mentioning. As long as $b^*_s(Fr, B) > e$ is satisfied, $H = Fr$ remains constant, while asset accumulation raises the relative price of good L and the unskilled wage and thus inequality between skilled and unskilled workers falls over time. However, once the economy enters the region $b^*_s(Fr, B) < e$, $H = Fr$ starts to decline, which affects the unskilled wage and the inequality negatively. The rising price of good L chokes off the moderate development process eventually.[26]

The result shows that, when the sectoral shift of consumption is introduced, a certain level of productivity in sector L becomes a *prerequisite* for the sectoral shift, and without it, the economy is destined to converge to a steady state with lower output and higher inequality. By contrast, when there is no sectoral shift of consumption, i.e. $\widetilde{c_L} = 0$, the structural change happens even when the productivity of sector L is low, as long as the economy starts with a 'right' wealth distribution. This is because people always spend a fixed portion of their incomes on each of the goods and transfers, hence the rising price of good L does not have a negative effect on transfer levels of skilled workers.

5.3 Productivity growth

The introduction of productivity growth does not change the main results of this section, but unlike the economy without the sectoral shift of consumption, the phase diagram is not qualitatively same as the one without productivity growth. The reason is that, even after adjusted for the productivity growth in sector H, $Fr = H^e(B; A_{L,t})$, $b^*_s(Fr, B; A_{L,t}) = e$, and $b^*_u(Fr, B; A_{L,t}) = e$, shift upward with the growth of $A_{L,t}$. This complication brings some new phenomena to the dynamics.[27]

First consider the case where the initial productivity of sector L is high so that the phase diagram in the initial period looks like the one in Section 3 (Figure 4). When Fr_0 is sufficiently large or small, the results of the model without productivity growth go through. A new possibility arises when Fr_0 is of an intermediate size. In this situation, an economy initially experiencing sectoral shift may end up in a low-output and high-inequality steady state. This can happen if wealth is relatively concentrated in the rich, consequently an increase in the number of skilled workers cannot keep up with an outward shift of $b^*_u(Fr, B; A_{L,t}) = e$ resulting from the productivity growth in sector L. Unskilled workers can increase transfers rapidly enough to keep up with a rising cost of education, if their income growth or a fall of the price of good L are fast enough. Given other things equal, the productivity growth makes the good cheaper but *decreases* the relative wage

[26]Relatedly, the possibility that a rising food price produced in the traditional sector could choke off development process is shown in the Lewis's (1954) model of a dual economy. The mechanism is that a wage increase caused by a rising food price reduces profits of the modern sector, lowers savings by capitalists and thus capital accumulation.

[27]The detailed analysis is available from the author upon request.

of unskilled workers. It turns out that its net effect on their asset accumulation and transfers is *negative*, that is, the growth of their transfers lag that of the cost of education. Thus the sectoral shift is halted if the number of skilled workers and aggregate assets do not increase rapidly enough to support the unskilled wage.

When the initial productivity of sector L is low, the phase diagram in the initial period looks like the one presented earlier in this section (Figure 5). Obviously, the economy does not remain in this state forever, since the productivity growth eventually takes it to the high productivity case. However, it is very unlikely that the economy starting from this situation succeeds in the sectoral shift and reaches the equal-opportunity steady state in the long run. If the economy enters the high productivity case with small Fr, the structural change never starts. Entering the high productivity case with sizable Fr, on the other hand, requires large initial 'middle class' and rapid productivity growth in sector L, which is unlikely to be satisfied in poor countries.

6 Conclusion

There are two phenomena widely observed when an economy departs from an underdeveloped state and starts rapid economic growth. One is the shift of production, employment, and consumption from the traditional sector to the modern sector, and the other is a large increase in educational levels of its population. The question is why some economies have succeeded in such 'structural change', but others do not. In order to examine the question, this paper has constructed an overlapping generations model that explicitly takes into account the sectoral change and human capital accumulation as sources of development.

It has been shown that, for a successful structural change, an economy must start with an initial wealth distribution that enables a sufficient proportion of individuals to receive education. Once the economy initiates the 'take-off', the sectoral shift and human capital growth continue until it reaches the steady state, where equal opportunity is attained. However, when the productivity of the traditional sector is low, the economy does not succeed in the sectoral shift irrespective of the initial distribution and modern sector productivity. Thus sufficient productivity in the traditional sector is a prerequisite for successful development.

The main points of the paper, (i) the importance of initial wealth distribution, especially the size of 'middle class', in economic development, and (ii) sufficient productivity in the traditional sector as a precondition for a successful sectoral shift, are largely supported by empirical studies.

Supportive evidences on the second point are more indirect, and it may be worthwhile to test this point in a more formal manner. One simple test would be a regression of an economy's output growth on initial productivity in the traditional sector and other controls including an initial size of 'middle class'.

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